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U. S. NAVAL TECHNICAL MISSION TO JAPAN
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SAN FRANCISCO, CALIFORNIA

2 January 1946

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From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Japanese Radar Countermeasures and Visual Signal Display Equipment.

Reference: (a)"Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, dealing with Targets E-07 and E-25 of Fascicle E-1 of reference (a), is submitted herewith.

2. The report was prepared by Lt. Comdr. M.C. Mains, USN, Ret., and is based upon personal interrogation and material gathered by Lt. Codm. F.M. Myers, USNR, Lieut. E.E. Schwalm, USNR, and Lieut. J.R. Dannemiller, USNR.

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31045

JAPANESE RADAR COUNTERMEASURES AND VISUAL SIGNAL DISPLAY EQUIPMENT

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945

FASCICLE E-1, TARGET E-07

JANUARY 1946

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

ELECTRONICS TARGETS

JAPANESE RADAR COUNTERMEASURES AND VISUAL SIGNAL DISPLAY EQUIPMENT

The Japanese had reached approximately the stage in countermeasures development that was reached in the United States in 1942. The Army took the lead in electronic jamming, although the Navy appears to have made the most effective use of "window", which was employed quite extensively by both services.

The Army and Navy had several types of intercept receivers of mediocre design, and accompanying antenna which provided a fair method of direction finding. There was nothing of intelligence value in test equipment, visual display or analyzing equipment.

Anti-jamming was understood only dimly, and there was no basic research on anti-jam circuits or techniques. The Japanese claimed some success in reading through "window" and "rope", but were helpless in the face of electronic jamming.

TABLE OF CONTENTS

REFERENCES

A. Location of Targets:

Second Naval Technical Institute, KANAZAWA, Kanagawa Prefecture.
Second Naval Technical Institute, Tokyo Branch, 13 Mita, Meguro Ku, TOKYO.
Naval Base, YOKOSUKA.
Naval Base, KURE.
Naval Base, SASEBO.
Mitsubishi, ITAMI.

B. Japanese Personnel Interrogated:

Vice-Admiral Takeishi NAWA, IJN, Head of Radar and Communications Department, Second Naval Technical Institute.
Captain Y. YAJIMA, IJN, Secretary to Vice-Admiral NAWA.
Captain Hisae TAKAHARA, IJN, Head of Direction Finder and Airborne Radar Section, Second Naval Technical Institute.
Lieut. T. IIDA, IJN, Second Naval Technical Institute.

C. Japanese Personnel Interviewed:

Comdr. ONO, IJN, former Radio Material Officer at Kure Naval Base.
Mr. T. SUMI, former Assistant RMO, KURE.
Lt. Comdr. Siezo MORI, Second Naval Technical Institute.
Mr. SHINKARA, Second Naval Technical Institute.
Mr. Fred K. UYEMINAMI, Second Naval Technical Institute, RDF and Airborne Radar Section, under Captain TAKAHARA. (Born Seattle, graduate University of Washington, 1933; graduate study at Massachusetts Institute of Technology. Later went to staff of Waseda University, and then became consultant to Japanese Navy. Age 33. Speaks fluent English.)
Mr. T. ISHIDA, Mitsubishi, ITAMI. (Worked on design of KUMO 4 intercept receiver.)
Mr. J. TOYODA, Mitsubishi, ITAMI. (Worked on design of TAKI 23 jamming equipment.)

D. Reports of Other Agencies:

Reports of Air Technical Intelligence Group, Far Eastern Air Forces (copies to Bureau of Aeronautics and Wright Field):

ATIG #101 - Japanese Radar Deception Buoys.
ATIG #115 - A Short Survey of Japanese Radar.
ATIG #153 - Japanese Radar Countermeasures.
ATIG #203 - American Radar Countermeasures vs Japanese Flak and Early-Warning Radar.
ATIG #276 - Catalog of Japanese Radio, Radar and Special devices.
ATIG #277 - Miscellaneous Electronics Documents, sent to Wright Field.
ATIG #278 - Organization, List of Reports and Equipments, ATIG Electronics Section.

Reports of Technical Liaison and Investigation Department, Office of Chief Signal Officer, General Headquarters, Supreme Commander Allied Powers (available from G-2, War Department, Washington, D.C.).

LIST OF ENCLOSURES

(A) List of Documents Forwarded to Washington Document Center.

(B) List of Equipment Seized.

(C) Description and Block Diagram of Taki-23 Jamming Equipment.

(D) Antenna Radar Interceptor.

(E) Schematic of FTC Airborne Intercept Receiver.

(F) Schematic of FTB Airborne Intercept Receiver.

(G) Chart of Japanese Navy Intercept Receivers and Antennae.

(H) Schematic of E-27 Intercept Receiver.

INTRODUCTION

Intelligence and combat reports prior to the end of hostilities had indicated no definitely confirmed use by the Japanese of radar countermeasures, other than confusion reflectors ("window"). It was desired to determine whether any electronic jamming devices had been used or were in process of development, and, in general, the state of progress in countermeasures. For this purpose, personnel in operational, installation, and maintenance and developmental branches of the Japanese Navy were interviewed, visits were made to the Naval Bases at KURE, SASEBO, and YOKOSUKA, and an effort was made to obtain samples of all equipment whose existence was established. Close liaison was maintained with other agencies covering the same field, in particular, the Electronic Section, Air Technical Intelligence Group, Far Eastern Air Forces, and the Technical Liaison and Investigation Department, Office of the Chief Signal Officer, Supreme Commander Allied Powers. It was ascertained early in the mission that the two agencies mentioned were covering the field of countermeasures very thoroughly. Hence, in order to avoid duplication, all useful information on countermeasures obtained by NavTechJap was furnished to these agencies for use in preparation of their reports, which should be consulted for detailed information. This report, therefore, is brief and covers only the general scope and the more salient features of Japanese countermeasures.

THE REPORT

A. ELECTRONIC JAMMING

The Japanese Army took the lead in electronic jamming. The Navy had one item of equipment under development designated FD-7, covering the range 140 to 160 mc, 30 watts, barrage over the band. More details of this jammer will be found in ATIG Report No. 153.

Detailed descriptions of Army jammers will be found in ATIG Report No. 115 and No. 153, and in TLID reports. Only two are of particular note, the TAKI 8 and TAKI 23. Both are transponder or "Moonshine" type equipments, TAKI 8 covering from 7 to 1.5 meters, 50 watts average, 500 watts peak, and TAKI 23 from 1.5 to 0.8 meters, 10 watts average, 100 peak. A description and block diagram of TAKI 23 furnished by Mr. J. TOYODA of Mitsubishi, ITAMI, is appended as Enclosure (C).

No expendable jammers of any type were used by the Japanese Navy. The Navy had planned to try jamming at the intermediate frequency of U.S. equipment, but nothing was done.

B. INTERCEPT AND ANALYZING EQUIPMENT

The Japanese had four types of intercept receivers three of which were in operational use. Designations and characteristics were as shown in Enclosure (G). The shipborne models were to be installed on all major vessels, and some of the E-27 receivers were used in large naval aircraft. Further details on the airborne models and antennas used with them will be found in ATIG Report No. 153, together with descriptions of the Army intercept receivers.

There is no evidence that the Japanese had any type of spectrum or pulse analyzers or any means of "fingerprinting" intercepted signals, other than determination of frequency and a crude approximation of pulse repetition frequency.

The Japanese Army had one type of recording receiver, the TAKI 4, described in ATIG Reports No. 115 and 153.

The problem of image-rejection seems to have been given little or no attention, although spurious responses were cited as a weakness of the FTB airborne intercept receiver.

The KUMO 4 was an intercept receiver covering 105 to 210 mc on the fundamental, up to 700 mc on the harmonics. The intermediate frequency was 25 mc, bandwidth 200 kc, gain 100 db. Tube line-up was as follows:

Mixer, 2	UN955 in pushpull
Local Osicllator	UN955
Inter Amp.	2A05A, 6 stages
2nd Det.	2A05A
AF Amp.	2A05A
Rectifier	UZ41

This receiver had both hand tuning and motor drive. A notable feature was the unit-construction of the 6 IF stages. It was similar in many respects to the TAKI 4, but lacked the recording feature.

Two complete sets of equipments were obtained and shipped to the U.S. for further study.

C. DECEPTION AND CONFUSION DEVICES

"Window" was used on quite a large scale, and with some success, by Japanese naval aircraft. Tactical employment is described in some detail in ATIG Report No. 153. There appears to have been little thought given to improving the type of "window", or to methods of dispensing, except for the "window" bomb, described in earlier intelligence reports and in ATIG Report No. 153. Attempts were made to develop "window" for use at 10cm, but were unsuccessful because of the large number of strips necessary to produce an echo at the required range. Operational tactics in the use of window are described in considerable detail in ATIG Report No. 153.

It appears that no type of confusion reflectors, other than "window", was used, although it was planned to use corner-reflectors (of two planes) suspended from balloons, against U.S. 10cm radar, also to plant metallic hemispheres in devasted areas to produce false targets. The Army had also developed a radio deception buoy, not very successfully, which is described in ATIG Report No. 101.

D. ANTI-JAMMING

The following anti-jamming measures were used by the Japanese:

1. Detuning. This was difficult because the Japanese sets were not tuned easily.

2. New frequency bands in new design. It was hoped, for instance, to escape jamming by using the Japanese version of the small Wuerzburg.

3. Use of gain-control. This apparently was not generally understood, as it was mentioned by only one person interviewed.

4. Discrimination against "rope" or "window" by observation of the fluctuation rate of the pips. This was claimed to have been about 80% effective.

5. Direction finding on the source of jamming to get azimuth for flak control. This apparently was not very successful. It was admitted that by July 1945, flak radar was only about 10% effective.

There appears to have been no knowledge of anti-jam circuits, such as wide-range gain control, fast-time-constant, etc., and it was stated that no A-J information was received from any foreign source.

ENCLOSURE (A)

LIST OF DOCUMENTS FORWARDED TO WASHINGTON DOCUMENT CENTER

NavTechJap No.	ATIS No.	Description
ND22-3005	4337	Installation instructions, radar and intercept receivers (ship).
ND22-3006	4338	Installation instructions, radar and intercept receivers (land based).
ND22-3007	4339	Instruction book for Type 4 Model 1 Modification 1 intercept receiver.
ND22-3009	4341	Detailed sketches, RCM antenna under development.
ND21-6161	3531	List of RCM equipment with characteristics (German intercept receiver).
ND21-6160-1	3394	Radar and radar intercept receivers, installation instructions.
ND21-6216.8-1	3532	Experimental report on submarine intercept receiver covered antenna.
ND21-6222	3533	Performance tests on Type 2 Mark 2 Model 1 radar antenna used for radar intercept purposes.
ND21-6234.1-1 to 6234.10-2	3534	Intercept receiver and antenna installation prints.
ND21-6280	3410	Performance of experimental parabolic antenna for radar intercept equipment.
ND21-6115-1	3524	Instruction book, radar intercept receiver.
ND21-6116	3525	Test on temporarily designated radar intercept receiver.
ND21-6117-1	3526	Experimental oscillator for radar intercept receiver; operating instructions.
ND21-6118-1	3527	Operating instructions, radar intercept receiver.
ND21-6119-1	3528	Operating instructions, improved type radar intercept receiver.
ND21-6120-1	3529	Improved installation, radar intercept receiver.
ND21-6122-1	3530	Operating instructions, radar intercept receiver.
ND21-6154-1	3535	E-27 intercept receiver, schematic.

ENCLOSURE (B)

I. LIST OF EQUIPMENT SEIZED BY NAVTECHJAP AND FORWARDED TO NRL

NavTechJap Equipment No.	
JE10-6103 thru 6106	Type 4 Model 3 Modif. 1 Intercept Receivers with one antenna (2 sets).
JE22-6132(A-D)	Type 4 Model 3 Intercept Receiver, with three types of antenna.
	Model 3 RCM Receiver (2 sets).
	E-27 (Mark 2 Modif. 4) Receiver (2 sets) with one antenna.
	KUMO 4 Intercept Receiver (2 sets).

II. LIST OF EQUIPMENT SEIZED BY ATIG FOR SHIPMENT TO FREEMAN FIELD, SEYMOUR, INDIANA

TAKI 23 Airborne Radar Jamming Equipment.

TAKI 4 Recording Intercept Receiver.

ENCLOSURE (C)

DESCRIPTION AND BLOCK DIAGRAMS OF TAKI 23 JAMMING EQUIPMENT
(description given as written in English by the Japanese.)

PRINCIPLE. Here we call the Radar, which is the object of bombardment, A, and TAKI 23, B. B receives impulse waves transmitted from A. B has the blocking oscillator, which has about 20 to 50 times the frequency of A-wave, and it is synchronized with the output of the received signal producing the new impulse waves. The ultra high frequency transmitter, which is one part of TAKI 23, is adjusted to the same wave length as A, and is modulated by these new impulse waves. Thus grow the radiating waves. When A receives it, we can see in the A oscilloscope many complicated images, and so can not see the image which returns from the object. Thus A loses its abilities.

USE. B has the construction illustrated in Figure I. B is set, receiver modulator and oscilloscope, with its multivibrator in action, transmitter in position about to start. First, B receives A-waves. Its output is watched continuously in the B oscilloscope. Second, the B transmitter is set in action, and is set in same wave length as A-wave. B receiver and B transmitter act upon each other from the output from multivibrator. As this mutual action is produced automatically we can see the double image (A signal and B signal) on the oscilloscope. According to the comparison of these two images on the oscilloscope, we adjust the modulating waves and synchronizing voltage to fix these two images, holding the frequency relation at 20 to 50.

As we watch the image on oscilloscope, we adjust the B transmitter to have the same wave length as the A transmitter, looking at the receiving postion on receivers dial.

ENCLOSURE (C), continued

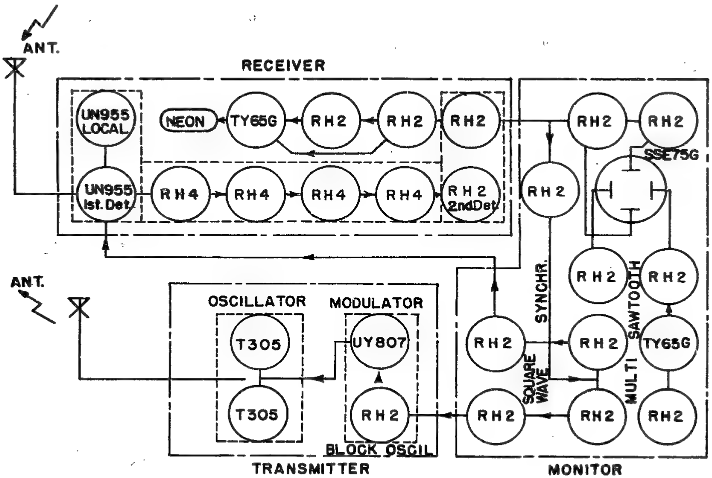


Figure 1

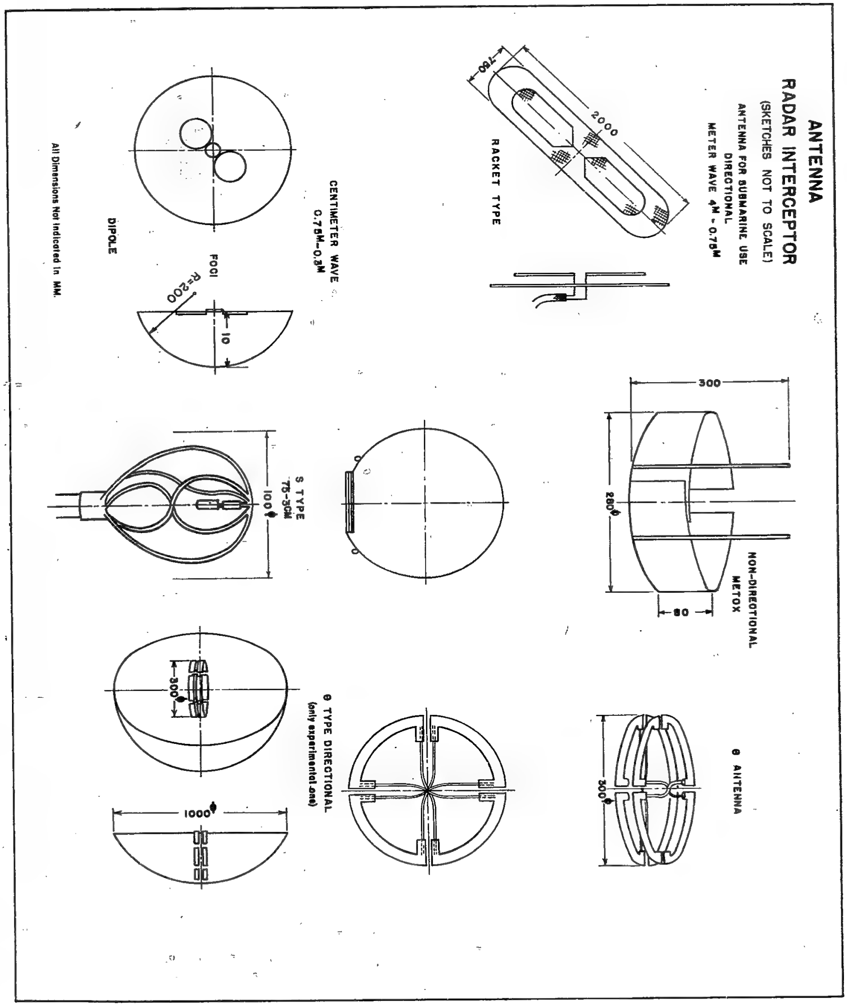
Notes:

Transmitter
- Tubes .... T 305 x 2
- Plate voltages .... 1500 V to 2200 V
- Oscillation range .... 75cm to 130cm
- Fixed gridbias .... -350 V (Grid modulated)

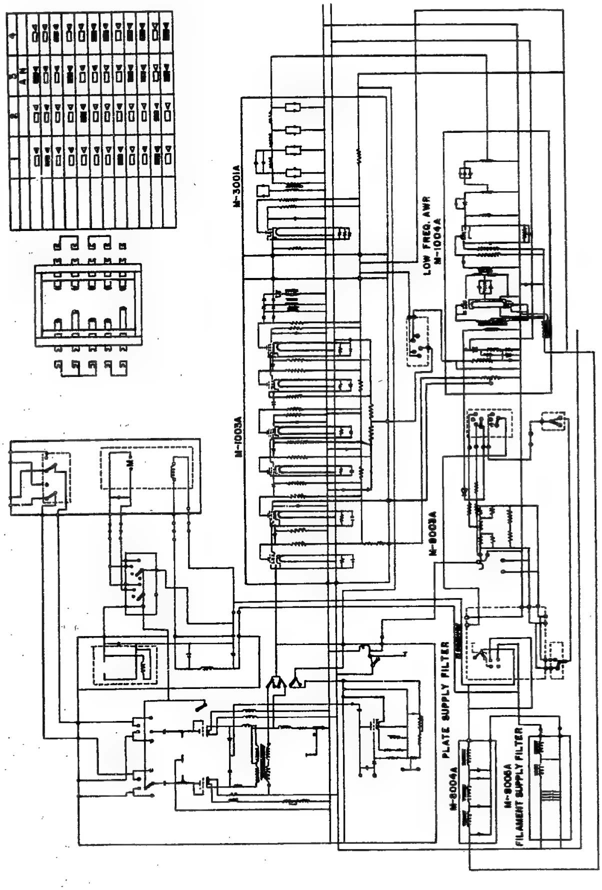
Modulator
- System: Impulse modulation by blocking oscillator, which is switch-controlled by square wave by multivibrator output.
- Impulse repeating frequencies .... 13 kc to 70 kc
- Modulator tubes .... UY 807 A
- Oscilloscope and other additional parts:
  - Braun tube .... SSE - 75 G (acceleration voltage 1200 V max.)
  - Relaxation saw tooth wave oscillator .... TY 65 G x 1
    .... RH 2 x 1
  - Sweep circuit amplifier .... RH 2 x 2
  - Multivibrator .... RH 2 x 2
  - Image amplifier synchronizing voltage amplifier ....
  - Switching voltage amplifier .... RH 2 x 5

Receiver
- System: Dual band super heterodyne .... 52cm to 120cm
  .... 97cm to 370cm
- Frequency converter .... UN 955 x 1
- Local oscillator .... UN 955 x 1
- Intermediate frequency amplifier .... RH 4 x 4 (bands - 200 kc)
  .... (gain 120 db)
- Audio, detector, audio frequency amplifier .... RH 2 x 2
- Neon indicator .... TY 65 G x 1
  .... RH 2 x 1

ENCLOSURE (D)

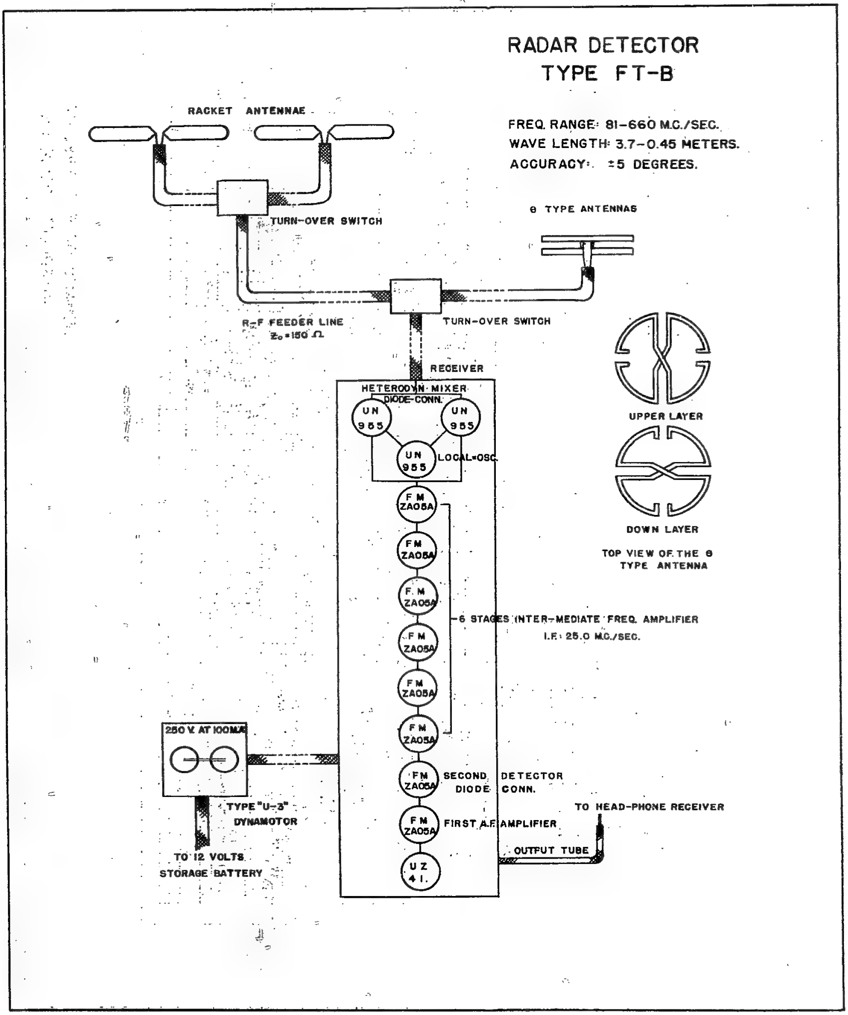

ANTENNA
RADAR INTERCEPTOR
(SKETCHES NOT TO SCALE)
ANTENNA FOR SUBMARINE USE
DIRECTIONAL
METER WAVE 4M - 0.75M
750
2000
RACKET TYPE
CENTIMETER WAVE
0.75M-0.3M
FOCI
R=200
10
DIPOLE
All Dimensions Not Indicated in MM.
S TYPE
75-3CM
100φ
300
280φ
80
NON-DIRECTIONAL
METOX
300φ
1000φ
θ TYPE DIRECTIONAL
(only experimental one)
θ ANTENNA
300φ

ENCLOSURE (E)

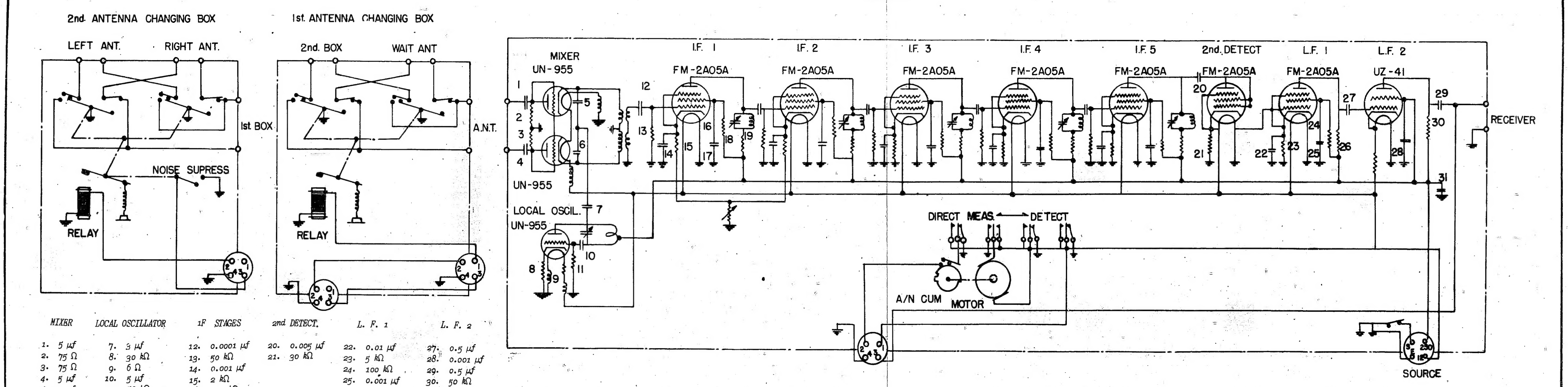


SCHEMATIC OF FTC AIRBORNE INTERCEPT RECIEVER

ENCLOSURE (F)


RADAR DETECTOR
TYPE FT-B
FREQ. RANGE: 81–660 M.C./SEC.
WAVE LENGTH: 3.7–0.45 METERS.
ACCURACY: ±5 DEGREES.
RACKET ANTENNAE
TURN-OVER SWITCH
θ TYPE ANTENNAS
R-F FEEDER LINE
Z₀=150 Ω
TURN-OVER SWITCH
RECEIVER
HETERODYN MIXER
DIODE-CONN.
UN 955
UN 955
UN 955
LOCAL-OSC.
UPPER LAYER
DOWN LAYER
TOP VIEW OF THE θ TYPE ANTENNA
FM ZA05A
6 STAGES INTER-MEDIATE FREQ. AMPLIFIER
I.F.: 25.0 MC./SEC.
250 V. AT 100MA
TYPE "U-3" DYNAMOTOR
TO 12 VOLTS STORAGE BATTERY
SECOND DETECTOR
DIODE CONN.
FIRST A.F. AMPLIFIER
TO HEAD-PHONE RECEIVER
OUTPUT TUBE
UZ 41.

ENCLOSURE (F)



MIXER	LOCAL OSCILLATOR	IF STAGES	2nd DETECT.	L. F. 1	L. F. 2
1. 5 μf	7. 3 μf	12. 0.0001 μf	20. 0.005 μf	22. 0.01 μf	27. 0.5 μf
2. 75 Ω	8. 30 kΩ	13. 50 kΩ	21. 30 kΩ	23. 5 kΩ	28. 0.001 μf
3. 75 Ω	9. 6 Ω	14. 0.001 μf		24. 100 kΩ	29. 0.5 μf
4. 5 μf	10. 5 μf	15. 2 kΩ		25. 0.001 μf	30. 50 kΩ
5. 2 μf	11. 50 kΩ	16. 100 kΩ		26. 10 kΩ	31. 1 μf
6. 2 μf		17. 0.001 kΩ			
		18. 10 kΩ			
		19. 59 kΩ			

Schematic of FBT Airborne Intercept Receiver

No.	Name	Designation	Object	Research		Remarks	Installation	Frequency Wave Length	Power Output (Peak)	Pulse Length	Repetition Frequency	Transmitter		Receiver		
				Started	Finished							Oscillation Circuit	Oscillator Valve	Intermediate Frequency	Detector	Local Oscillator
1	Type-3 Air Mark-6 Model-4 Radio	H-6	Patrol and search	11/41	8/22	in use	Large and Small Aircraft, Observer's Seat	2m	3kw	10ms	1000c/s	Blocking Oscillator	U-233 x2	10mc	1st UN-95A 2nd FM-2A05A	UN-955
2	Type-4 Air Mark-6 Model-3 Radio	FH-1	Patrol and search	2/44	9/44	out of use	Small Aircraft, Observer's Seat	2m	4.2kw	15ms	250c/s	Modulated Oscillator	T-319 x2	10mc	1st UN-954 2nd SORA	UN-955
3	Prototype 19 Air Mark-1 Model-12	FK-3	Patrol and search	10/44	6/45	Not yet used	Small Aircraft, Observer's Seat	2m	2kw	10ms	1000c/s	Blocking Oscillator	U-233 x2	10mc	1st UN-954 2nd FM-2A05A	UN-955
4	Warning Radar for Large Aircraft	FK-4	Patrol and search	6/44	7/45 Stopped	research stopped		2m	20kw	20ms	83c/s(500 c/s x 1/6)	Modulated Oscillator	K-3006 x2	10mc	1st UN-954 2nd SORA	UN-955
5	Prototype 19 Air Mark-1 Model-11 Radar	N-6	Patrol and search	3/43	10/44 Stopped	not yet used	Small Aircraft, Observer's Seat	1.2m	2kw	5ms	1000c/s	Modulated Oscillator	T-319 x2	10mc	1st UN-954 2nd FM-2A05A	UN-955
6	Prototype 18 Air Mark-6 Model-2 Radio	FD-1	Patrol and search	12/43	2/44 Stopped	not yet used		60cm	2.5kw	3ms	1000c/s	Modulated Oscillator	T-321 x1	10mc	1st 2400 2nd FM-2A05A	UN-955
7	Prototype 18 Air Mark-6 Model Radio	FD-2	Night fighter	4/44	8/44	not yet used	Transmitter--Head, Indicator Observer's Seat	62m	2.5kw	3ms	1000c/s	Modulated Oscillator	T-321 x1	10mc	1st 2400 2nd FM-2A05A	UN-955
8	Prototype 19 Air Mark-2 Model-11 Radar	Gyoku-3	Night fighter	9/44	7/45	not yet used		2m	3kw	2ms	2500c/s	Modulated Oscillator	T-319 x2	17.75mc	1st UN-954 2nd SORA	UN-955
9	Prototype 5 Model-1 IFF	M-13	IFF (Friend aircraft locating)	10/44	7/45	not yet used	Bottom	2m	50w	0.6ms		Modulated by Thyratron	T-304		UN-955	
10	Prototype Model-1 Height Measurering Radar	FH-1	Height measure		2/45	in use	In the Wings	340mc~15mc	0.1w	Continous		Self Oscillator	T-304-A		UN-955	M-60
11	Prototype 19 Air Mark-3 Model-30 Radar	51	Path finder	9/44		on test		10cm	6kw	14ms	600c/s	Magnetron	M-314	14mc	1st Crystal 2nd	UN-955
12	Prototype 2 Air Mark-7 Model-2 Radio	FT-B	Radar counter measure	1/43	5/44	not yet used	Large Aircraft, Observer's Seat	3.7m~0.45m						25mc	1st UN-955x2 2nd FM-2A05A	UN-955
13	Prototype 2 Air Mark-7 Model-3 Radio	FTC	Radar counter measure				Large Aircraft, Observer's Seat	3.7m~0.45m						0~1mc	1st UN-955x2 2nd SORA	UN-955

No.	Na	Designation	Object	Research.		Remarks	Instal	Frequency Band (Wave length)	Receiver					of Indication
				Started	Finished				Type	Local Oscillator	Intermediate Frequency	Tubes	Gain	
1	Radar Counter Measure Kai 3	E 27	RCM for meter-wave	6/43	4/44	in use	Surface Ships and Submarines	7.5mc~400mc (4m~0.75m)	Single Tuning Superheterodyne	Parallel Wire Single Tuning	14.5mc	Un-955x3 UZ-606x9	110db	Aural Visual: For Directional and Repetition Frequency
2	Radar Counter Measure Model-3		RCM for cm-wave	1/44	4/44	in use	Surface and Submarine (Land)	400mc~10,000mc (0.75m~0.08m)	Crystal Detecto		17.5±3.5mc	UZ-606x4 UZ-42x1	110db	Aural Visual: For Directional and Repetition Frequency
3	Racket-antenna		RCM for meter-wave	6/43	12/44	in use	Surface and Submarine	4m~0.75m		Receiver Used, Kai-3 (E-27)				
4	Metox-antenna		RCM for meter-wave	6/43	12/44	in use	Surface and Submarine	4m~0.75m		Receiver Used, Kai-3 (E-27)				
5	θ - antenna		RCM for meter-wave	6/44	12/44	not yet used	Surface and Submarine	4m~0.75m		Receiver Used, Kai-3 (E-27)				
6	Mark-49 Antenna		RCM for cm-wave	6/44	12/44	in use	Surface and Submarine, Land	0.80m~0.03m		Receiver Used, Model-3				
7	Spherical Antenna		RCM for cm-wave	3/45	7/45	not yet used	Surface and Submarine, Land	0.15m~0.03m		Receiver Used, Model-3				

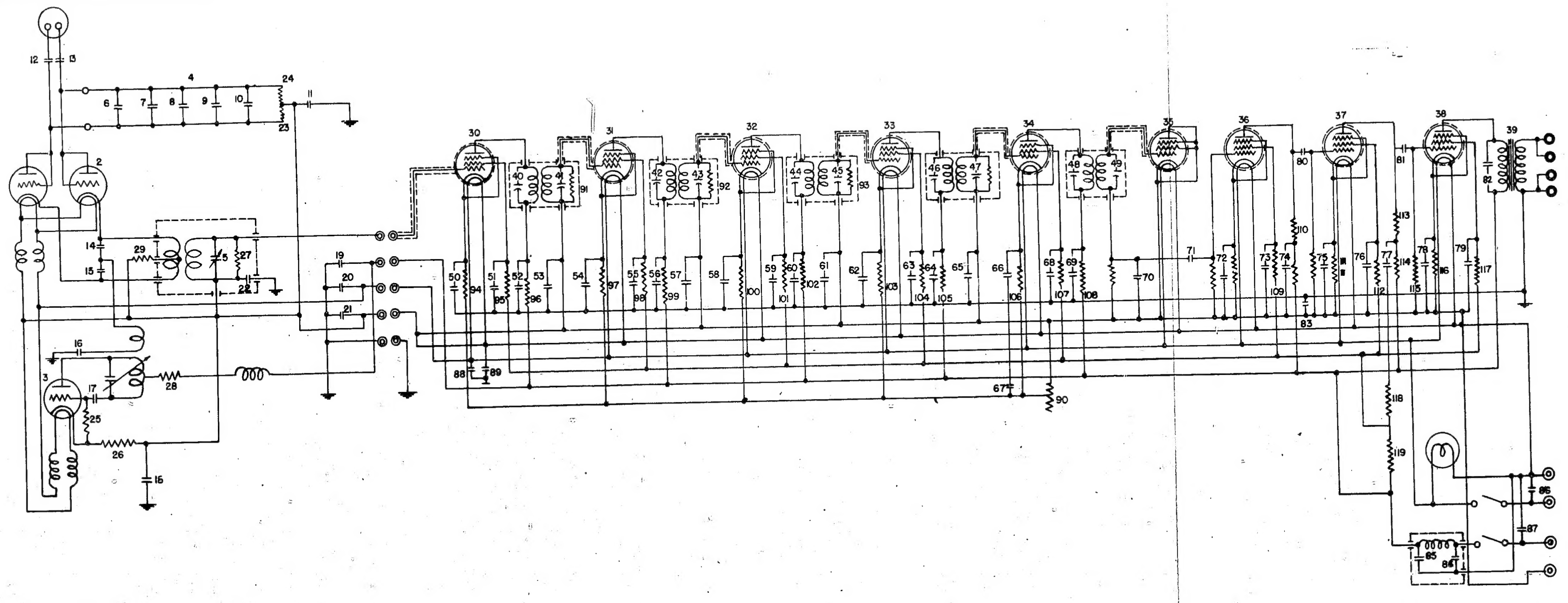
Chart of Japanese Navy Intercept Receivers and Antennas

ENCLOSURE (G), continued

Scope Representation					Beam Angle												
Dia. (mm)	Scanning Axis	Scale	Type	Gain	Horizontal	Vertical	Max. Range (Max. Effective Scale)	Minimum Distance	Accuracy of Range	Distance Discrimination	Accuracy of Bearing	Angle Discrimination	Spare Parts	No. of Operators	Degree of Operating Difficulty	Maintenance	No.
120	Linear	Mechanical	Head: Yagi Sides: Folded Doublet	16db 6.5db	$\theta_{1/2} = 30^\circ$ $\theta_{1/2} = 35^\circ$	$\theta_{1/2} = 28^\circ$ $\theta_{1/2} = 30^\circ$	150 (110 against a large Ship)	3 km(H=1000m)	$\simeq \pm 5\%$	2~3 km	$\pm 3^\circ$	$\simeq 60^\circ$		Radar Technician by large plane, Observer by small	None	Ordinary	1
120	Sinusoidal	Mechanical	Head: Yagi Sides: Folded Doublet	16db 6.5db	$\theta_{1/2} = 30^\circ$ $\theta_{1/2} = 35^\circ$	$\theta_{1/2} = 28^\circ$ $\theta_{1/2} = 30^\circ$	250 (110 against a large Ship)	5 km(H=1000m)	$\simeq \pm 5\%$	4 km	$\pm 3^\circ$	$\simeq 60^\circ$		Observer	None	Ordinary	2
75	Linear, Logarithmic	Mechanical	Head: Yagi Sides: Folded Doublet	16db 6.5db	$\theta_{1/2} = 30^\circ$ $\theta_{1/2} = 35^\circ$	$\theta_{1/2} = 28^\circ$ $\theta_{1/2} = 30^\circ$	150 (60 against a large Ship)	3 km(H=1000m)	$\simeq \pm 5\%$	4~5 km	$\pm 3^\circ$	$\simeq 60^\circ$		Observer	None	Ordinary	3
120	Linear	Mechanical	Head: Yagi Sides: Folded Doublet	16db 6.5db	$\theta_{1/2} = 30^\circ$ $\theta_{1/2} = 35^\circ$	$\theta_{1/2} = 28^\circ$ $\theta_{1/2} = 30^\circ$	300 (150 against a large Ship)	5 km(H=1000m)	$\simeq \pm 5\%$	5 km	$\pm 3^\circ$	$\simeq 60^\circ$		Radar Technician	None		4
75	Logarithmic	Mechanical	Head: Yagi Sides: Folded Doublet	16db 6.5db	$\theta_{1/2} = 30^\circ$ $\theta_{1/2} = 35^\circ$	$\theta_{1/2} = 28^\circ$ $\theta_{1/2} = 30^\circ$	150 (40 against a large Ship)	2.5 km(H=1000m)	$\simeq \pm 5\%$	1.5~2 km	$\pm 3^\circ$	$\simeq 60^\circ$	Number of Vacuum Tubes in Use x3	Observer	None	Ordinary	5
75	Sinusoidal	None	Yagi Antenna	8db	$\simeq 30^\circ$	$\simeq 30^\circ$	75 (20 against a large Ship)	600m	$\simeq \pm 5\%$	$\simeq$500 m	$\pm 0.5^\circ$	$\simeq 60^\circ$	Number of Resistances in Use x1	Observer	None	Ordinary	6
75	Sinusoidal	None	Yagi Antenna	8db	$\simeq 30^\circ$	$\simeq 30^\circ$	75 (3 against a large Ship)	600m	$\simeq \pm 5\%$	$\simeq$500 m	$\pm 0.5^\circ$	$\simeq 60^\circ$	Number of Condensers in Use x1	Pilot	None	Ordinary	7
75	Circular and Linear		Combination of θ Ant. and Doublet with Goniometer	2.5~3db	$\pm 70^\circ$	$\pm 70^\circ$	10 (4.5 against a large Ship)	400~600m	$\simeq \pm 5\%$	$\simeq$500 m	$\pm 5^\circ$	$\simeq 100^\circ$	Number of Fuses in Use x3	Pilot	None	Ordinary	8
	(Earpiece)		L-Shaped Antenna	nondirectional			110		About 0.8km with radar 62				Number of Transformers in use x1	Pilot	Slight	Ordinary	9
DC	D.C. Ammeter		Doublet	0db			0~200m (10m~150m)		$\simeq \pm 5\%$					Pilot Observer	None	Gave some trouble	10
120	Circular		Doublet with Parabolic Mirror	18db	$\pm 7^\circ$	$\pm 12^\circ$	100 (20)	$\simeq$1500m	Research Incomplete	Research Incomplete	Research Incomplete	Research Incomplete		Radar Technician	Slight	Ordinary	11
	(Earpiece)		Racket Ant. and θ Ant.	-5~-15db	$\pm 50^\circ$		over 250				$\pm 5^\circ$	$2\sim5^\circ$		Radar Technician	None		12
	(Earpiece and Meter)		Racket Ant. and θ Ant.	-5~-15db	$\pm 50^\circ$		over 250				$\pm 5^\circ$	$2\sim5^\circ$		Radar Technician			13

Antenna			Beam Angle							
Type	Kind	Gain	Horizontal	Vertical		Spare Parts	No. of Operators	Degree of Operating Difficulty	Maintenance	No.
Directional: Racket-antenna (Rotating Fixed for Surface craft) All-around: Metox-antenna or θ-antenna						Number of Vacuum Tubes in Use x3 Few Replacement Parts	one	None	No trouble	1
Directional: Parabolic Disc Type (Mark-49) (Portable) All-around: Spherical-antenna						Number of Vacuum Tubes in Use x3	one	None	No trouble	2
Rotating, Fixed	Directional	-3db	$30^\circ\sim50^\circ$	$30^\circ\sim50^\circ$				None	Liable to Insulation Breakdown	3
Fixed	All-around	-6db						None	Liable to Insulation Breakdown	4
Fixed	All-around	-6db						None	No trouble	5
Portable	Directional	+5db	$10^\circ\sim40^\circ$	$10^\circ\sim40^\circ$				Slightly Difficult aboard Subs	No trouble	6
Fixed	All-around	-20db						None	No trouble	7

ENCLOSURE (H)



NO.	VALUE	NO.	VALUE	NO.	VALUE	NO.	VALUE	NO.	VALUE	NO.	VALUE	NO.	VALUE	NO.	VALUE	NO.	VALUE	NO.	VALUE	NO.	VALUE	NO.	VALUE
1	uy - 955	11	100 µf	21	0.002 µf	31	uz - 666	41	30 µf	51	0.01 µf	61	0.01 µf	71	0.1 µf	81	0.1 µf	91	15 kΩ	101	2 kΩ	111	2 kΩ
2	uy - 955	12	100 µf	22	0.002 µf	32	uz - 666	42	30 µf	52	0.01 µf	62	0.01 µf	72	0.5 µf	82	0.0 µf	92	15 kΩ	102	2 kΩ	112	2 kΩ
3	uy - 955	13	100 µf	23	100 Ω	33	uz - 666	43	30 µf	53	0.01 µf	63	0.01 µf	73	0.5 µf	83	0.5 µf	93	15 kΩ	103	2 kΩ	113	20 kΩ
4	mc - 1041	14	20 µf	24	100 Ω	34	uz - 666	44	30 µf	54	0.01 µf	64	0.01 µf	74	0.5 µf	84	0.0001 µf	94	2 kΩ	104	2 kΩ	114	2 kΩ
5	30 µf	15	20 µf	25	30 kΩ	35	uz - 666	45	30 µf	55	0.01 µf	65	0.01 µf	75	0.5 µf	85	0.0001 µf	95	2 kΩ	105	2 kΩ	115	100 kΩ
6	1 µf	16	30 µf	26	100 Ω	36	uz - 666	46	30 µf	56	0.01 µf	66	0.01 µf	76	0.5 µf	86	0.01 µf	96	2 kΩ	106	2 kΩ	116	2 kΩ
7	3 µf	17	10 µf	27	15 kΩ	37	uz - 666	47	30 µf	57	0.01 µf	67	0.01 µf	77	0.5 µf	87	0.01 µf	97	2 kΩ	107	2 kΩ	117	2 kΩ
8	5 µf	18	200 µf	28	10 kΩ	38	uz - 666	48	30 µf	58	0.01 µf	68	0.01 µf	78	0.5 µf	88	0.01 µf	98	2 kΩ	108	2 kΩ	118	10 kΩ
9	10 µf	19	0.002 µf	29	100 Ω	39	1:1	49	30 µf	59	0.01 µf	69	0.01 µf	79	0.5 µf	89	0.01 µf	99	2 kΩ	109	2 kΩ	119	15 kΩ
10	10 µf	20	0.002 µf	30	uz - 666	40	30 µf	50	0.01 µf	60	0.01 µf	70	0.0001 µf	80	0.1 µf	90	10 kΩ	100	2 kΩ	110	100 kΩ		

Schematic of E-27 Intercept Receiver